Storage of CO_2 below the Seabed

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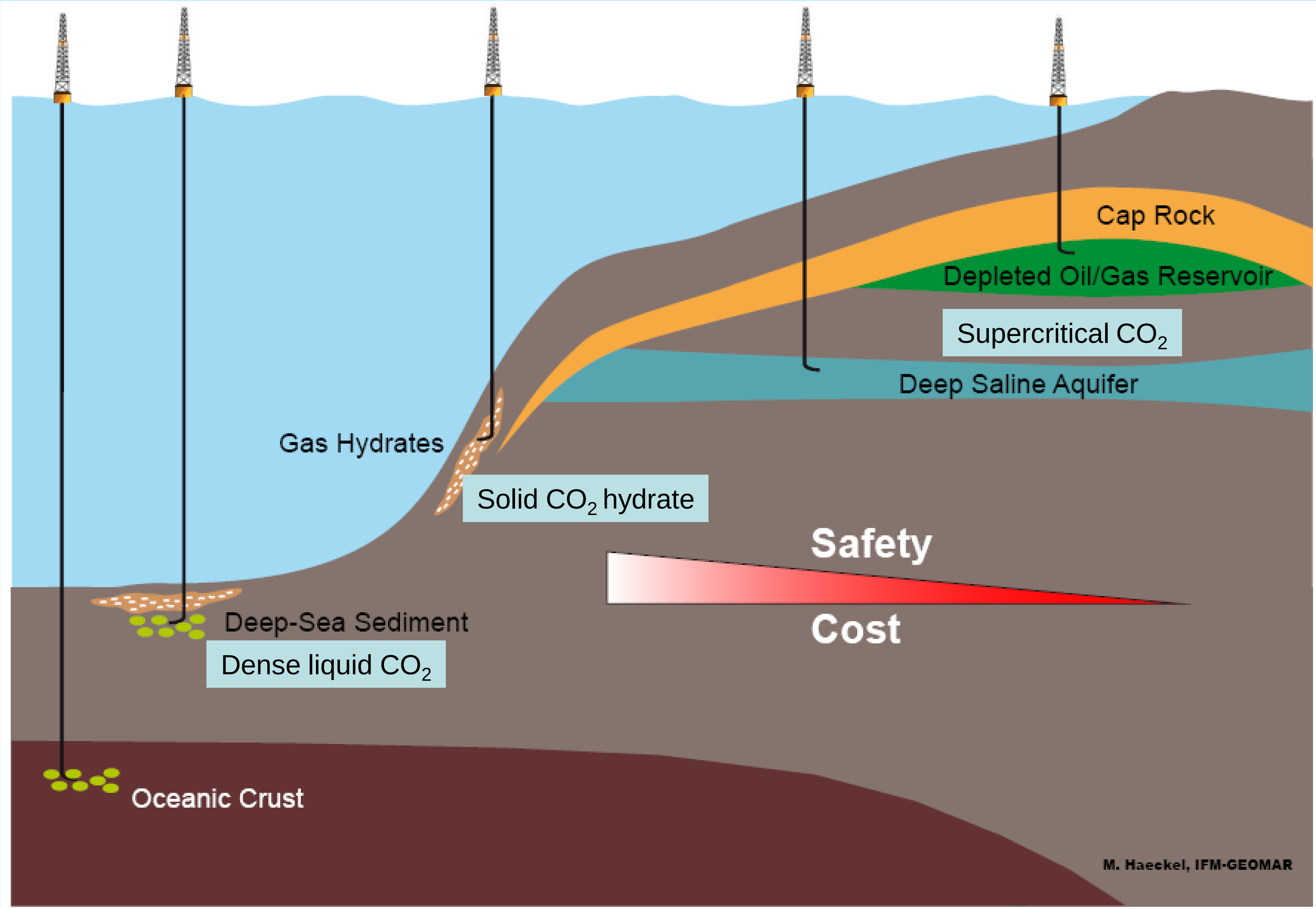
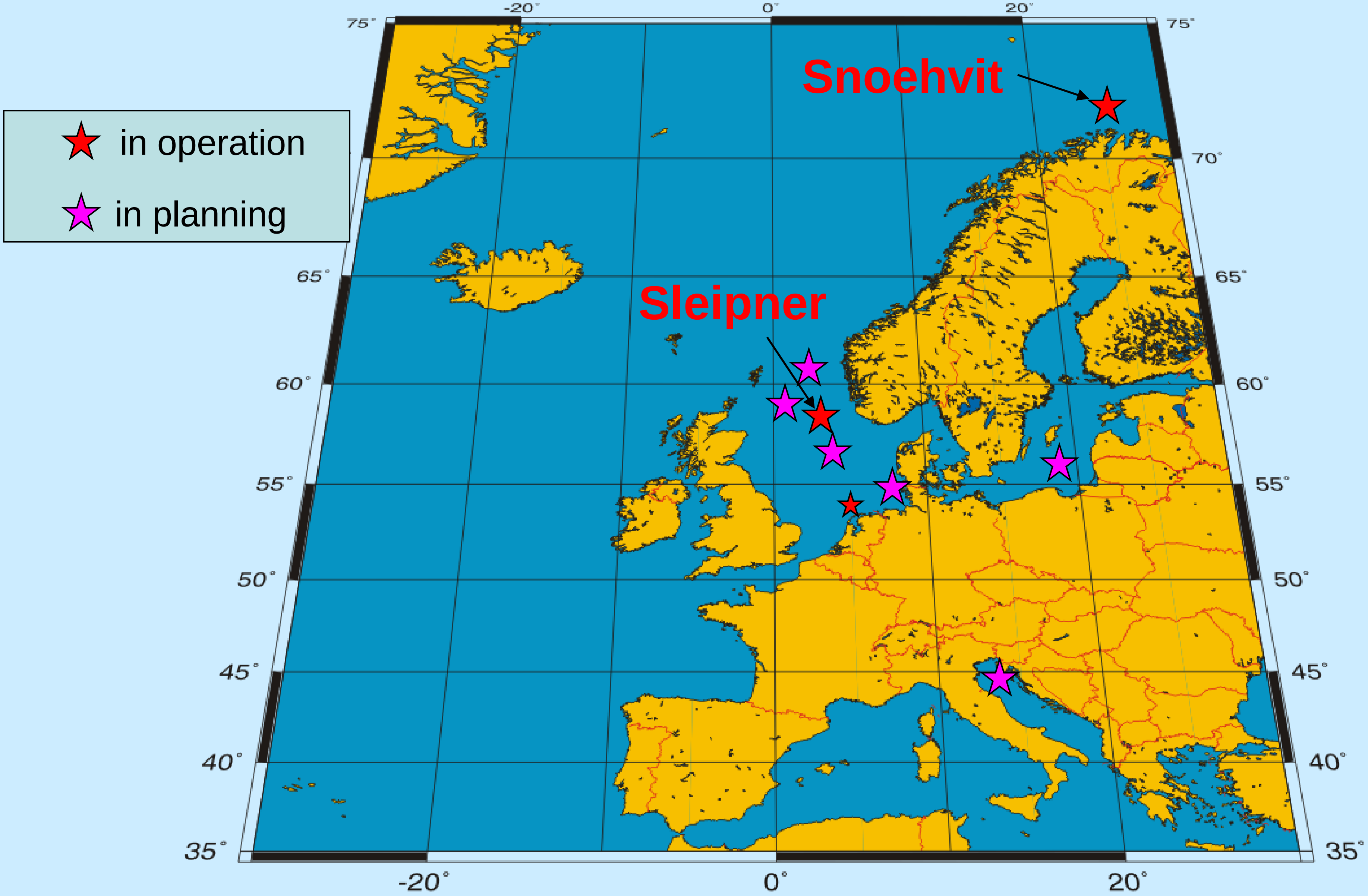
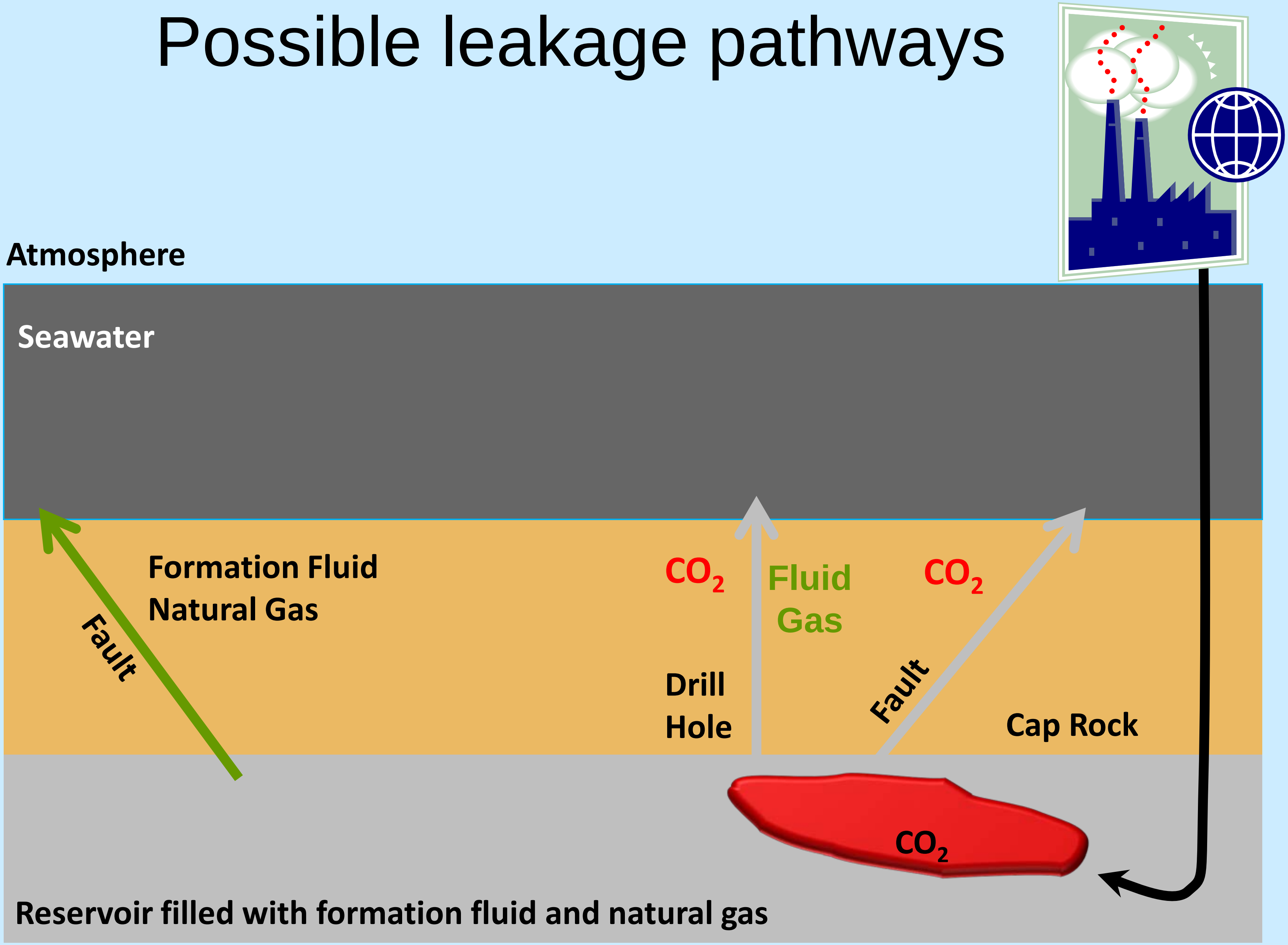
Storage Options Below the Seabed



CO_2 storage sites

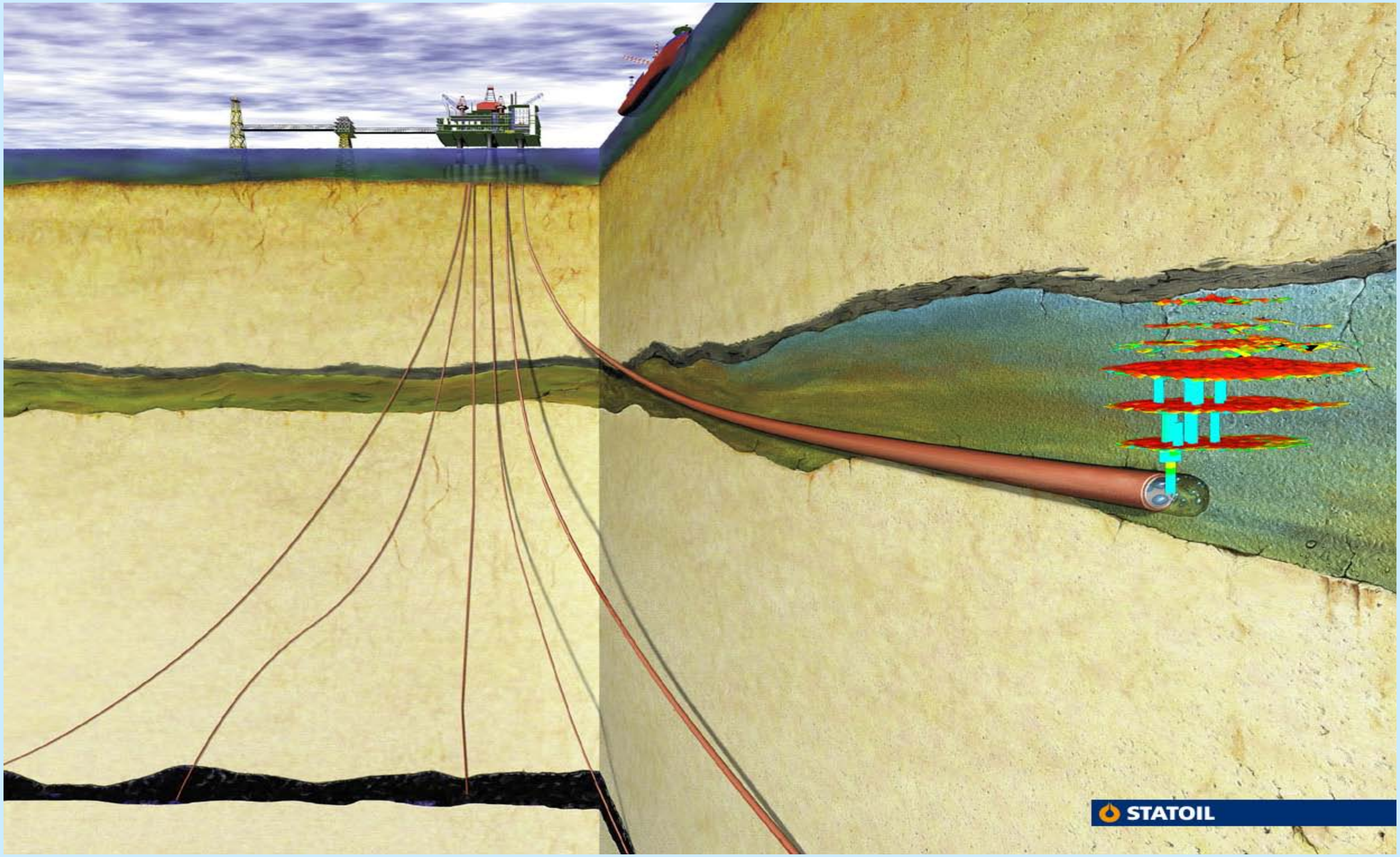


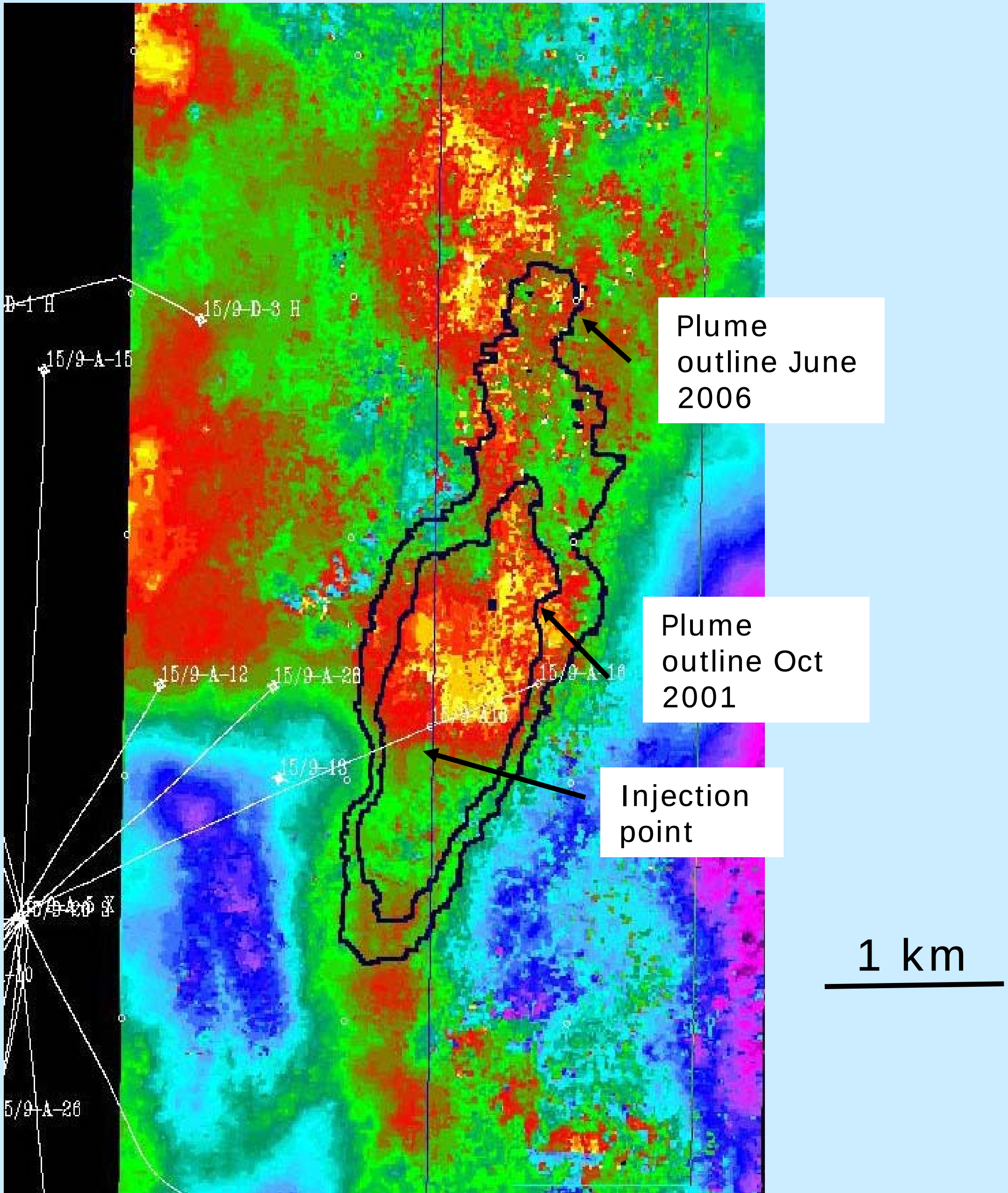
Possible leakage pathways



Sleipner

CO_2 separated from natural gas, 1 Mt CO_2/a, since 1996,
water depth: 80 m, sediment depths: 900 m





Sleipner

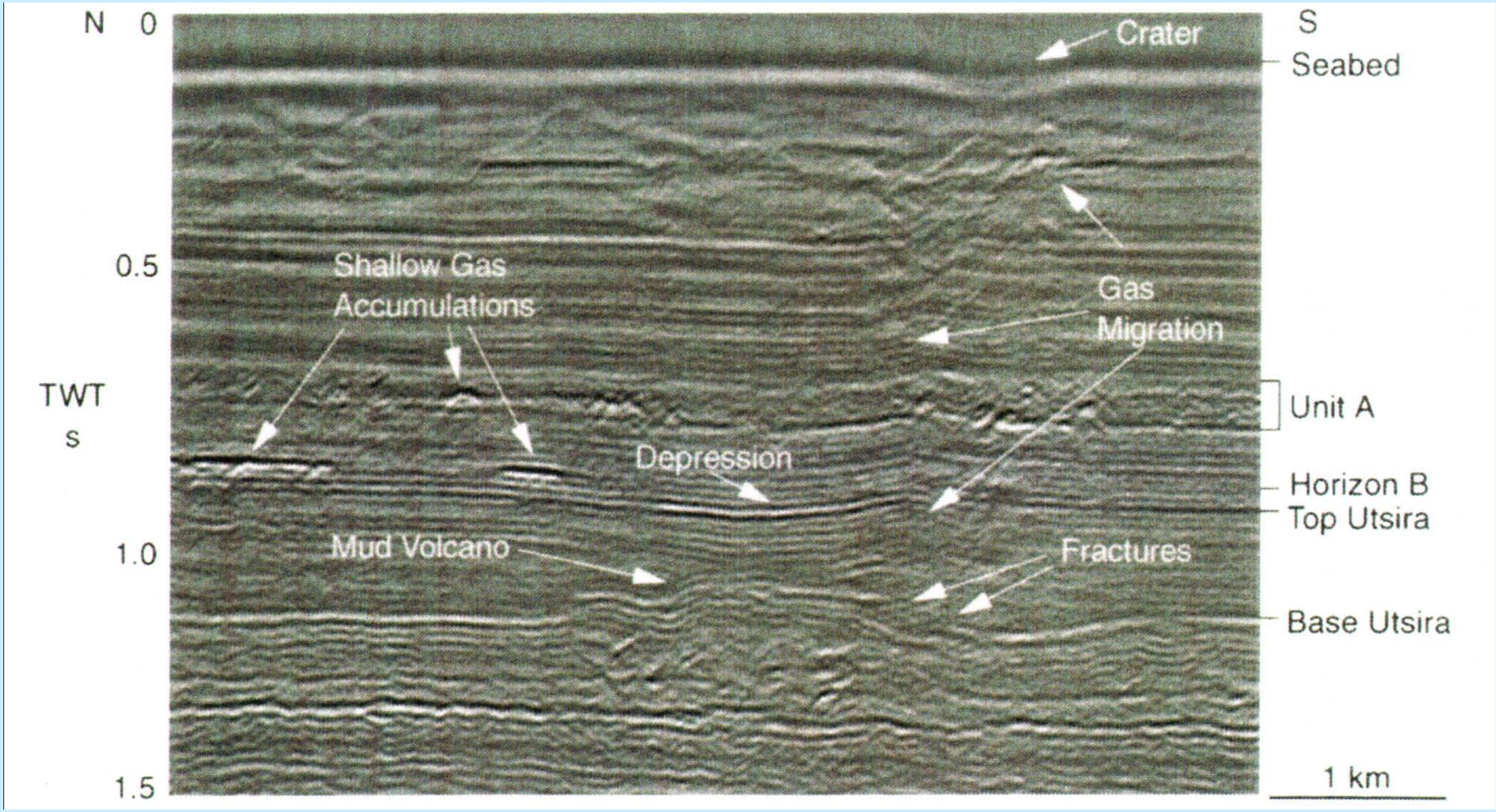
Lateral spread of CO_2 stored in the subsurface

Injected volume: >14 x 10^6 m^3

No pressure increase in the reservoir

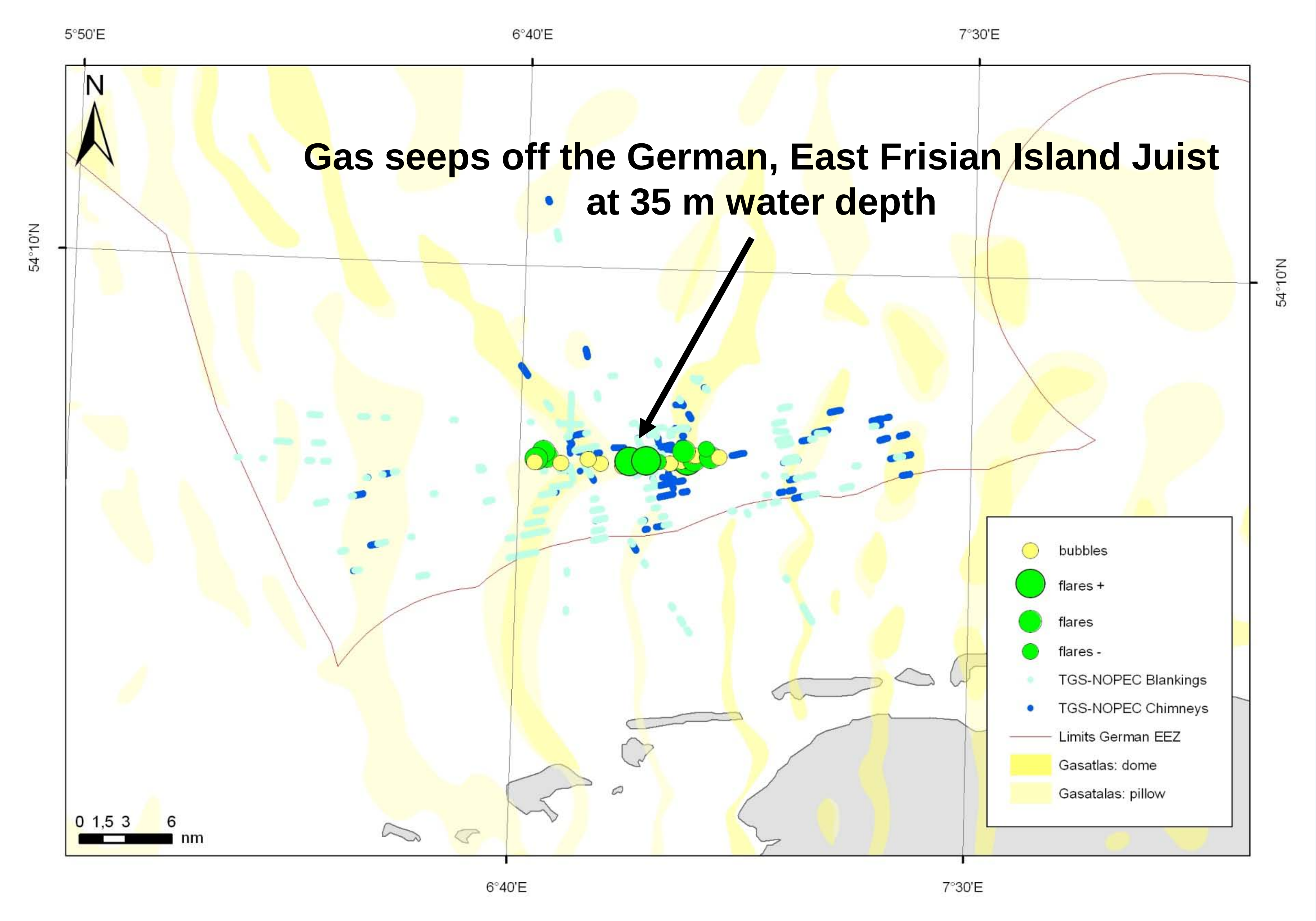
Source: StatoilHydro (2007)

Seepage of natural gas at Sleipner?



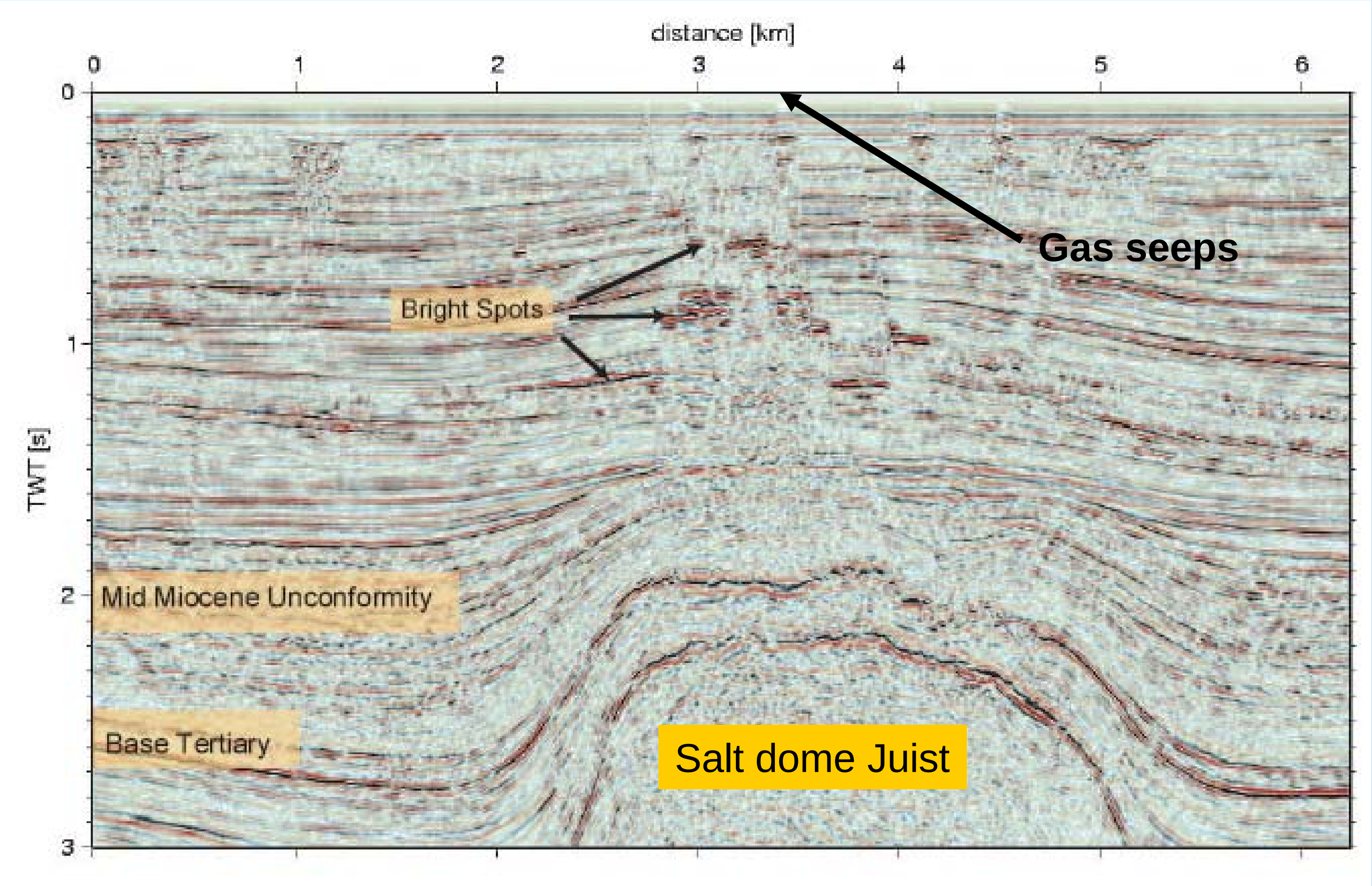
Source: Heggland (1997)

Natural CO_2 seepage in the North Sea



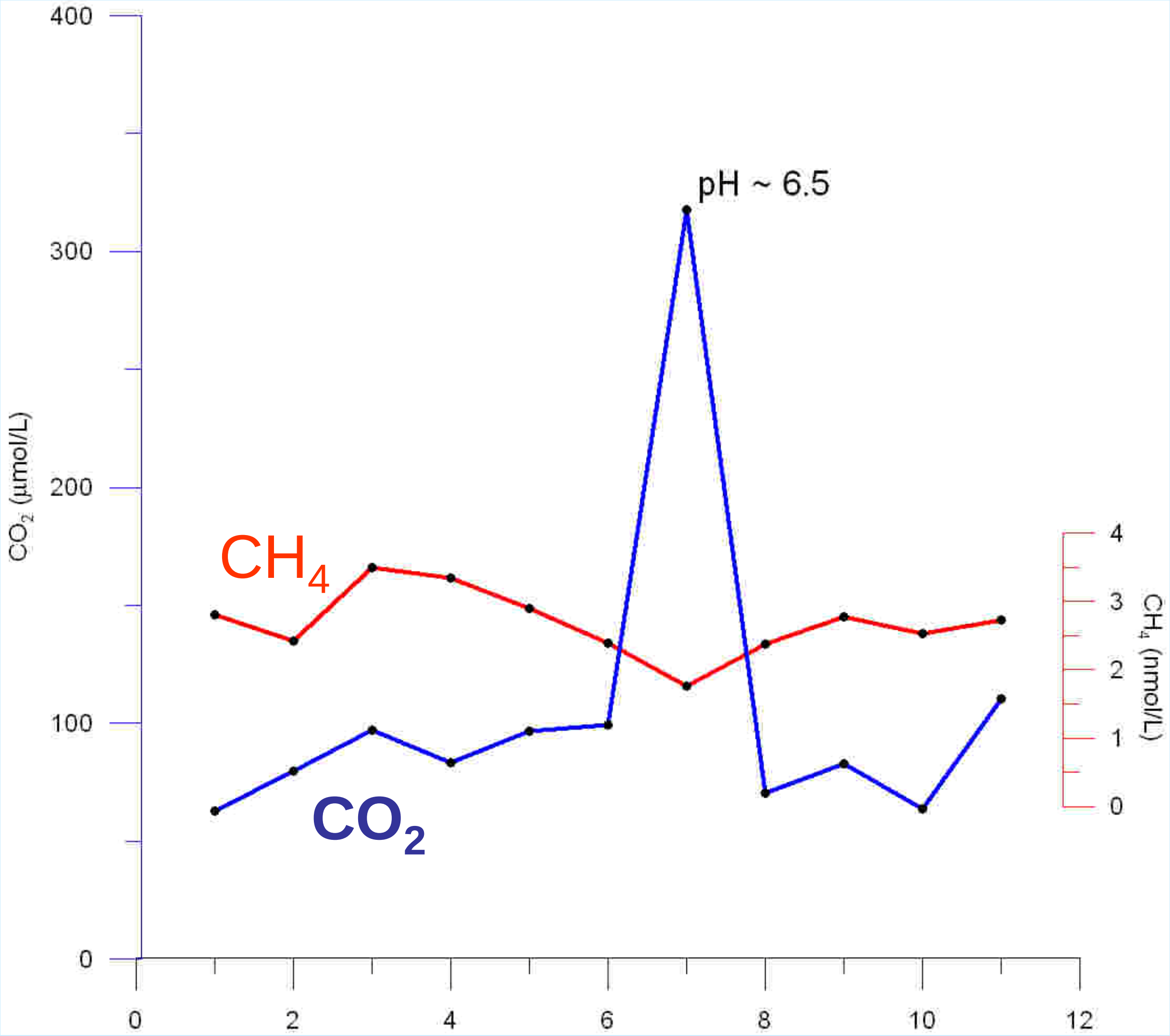
Source: Linke et al. (2009)

Natural CO_2 seepage in the North Sea



Source: Linke et al. (2009)

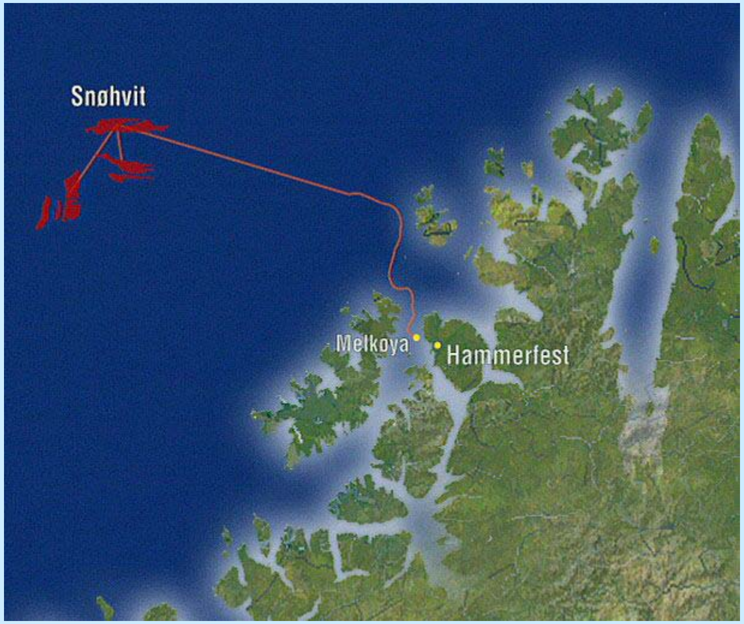
Natural CO_2 seepage in the North Sea

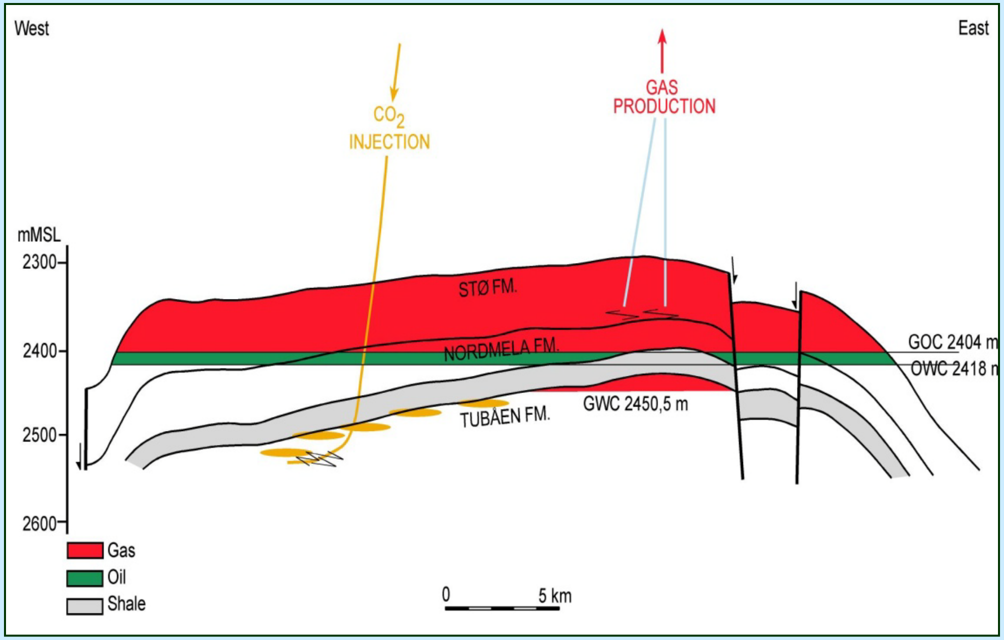


Chemical anomalies in bottom waters above the salt dome (CTD survey)

Source: Linke et al. (2009)

Snoehvit, Barents Sea



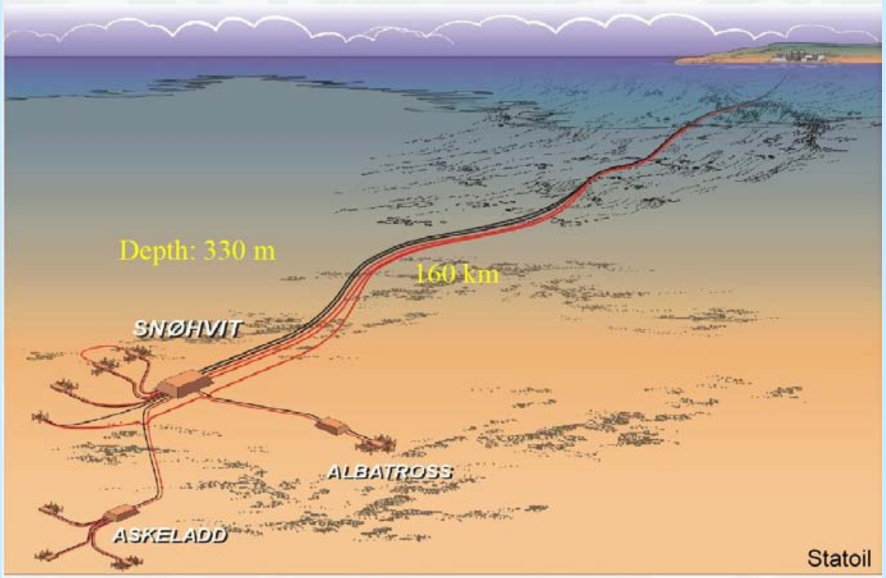


CO_2 separated from natural gas

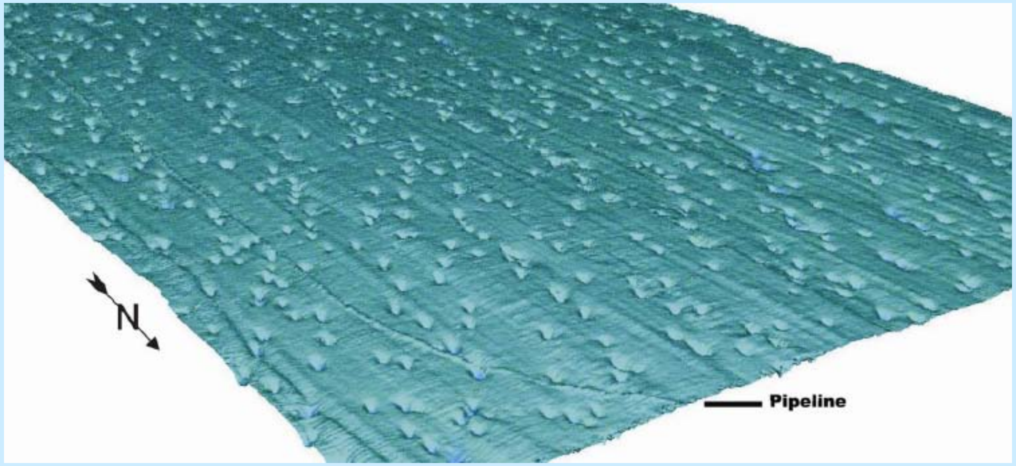
0,7 Mt CO_2/a, since 2009

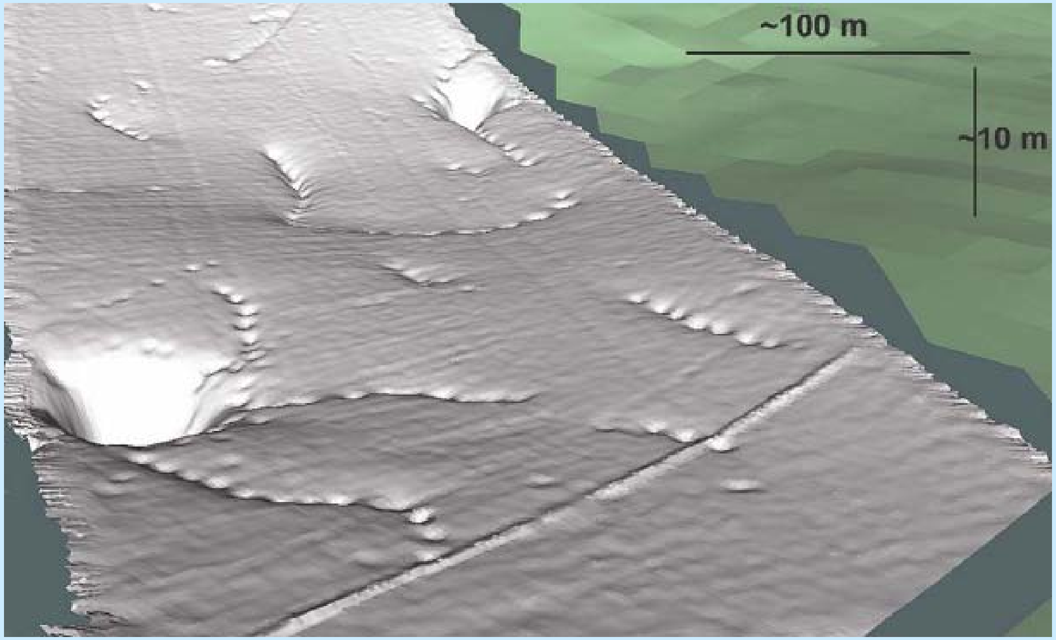
water depth: 330 m

sediment depth: 2600 m



Natural Seepage at the Seafloor
-Pockmarks-





Source: Judd & Hovland (2007)

Research and policy needs (geoscience perspective)

- survey the seafloor above geological formations currently used for CO_2 storage (Sleipner, Snoehvid) for natural and man-made seepage

- understand the geological, physical, and chemical controls on leakage of CO_2, formation fluids, and natural gas from sub-seabed geological formations through faults, fractures, boreholes and other high permeability conduits

- study natural seepage as precursor and analog for future CO_2 leakage from sub-seabed storage sites

- develop a monitoring scheme for the safe operation of present and future sub-seabed CO_2 storage sites

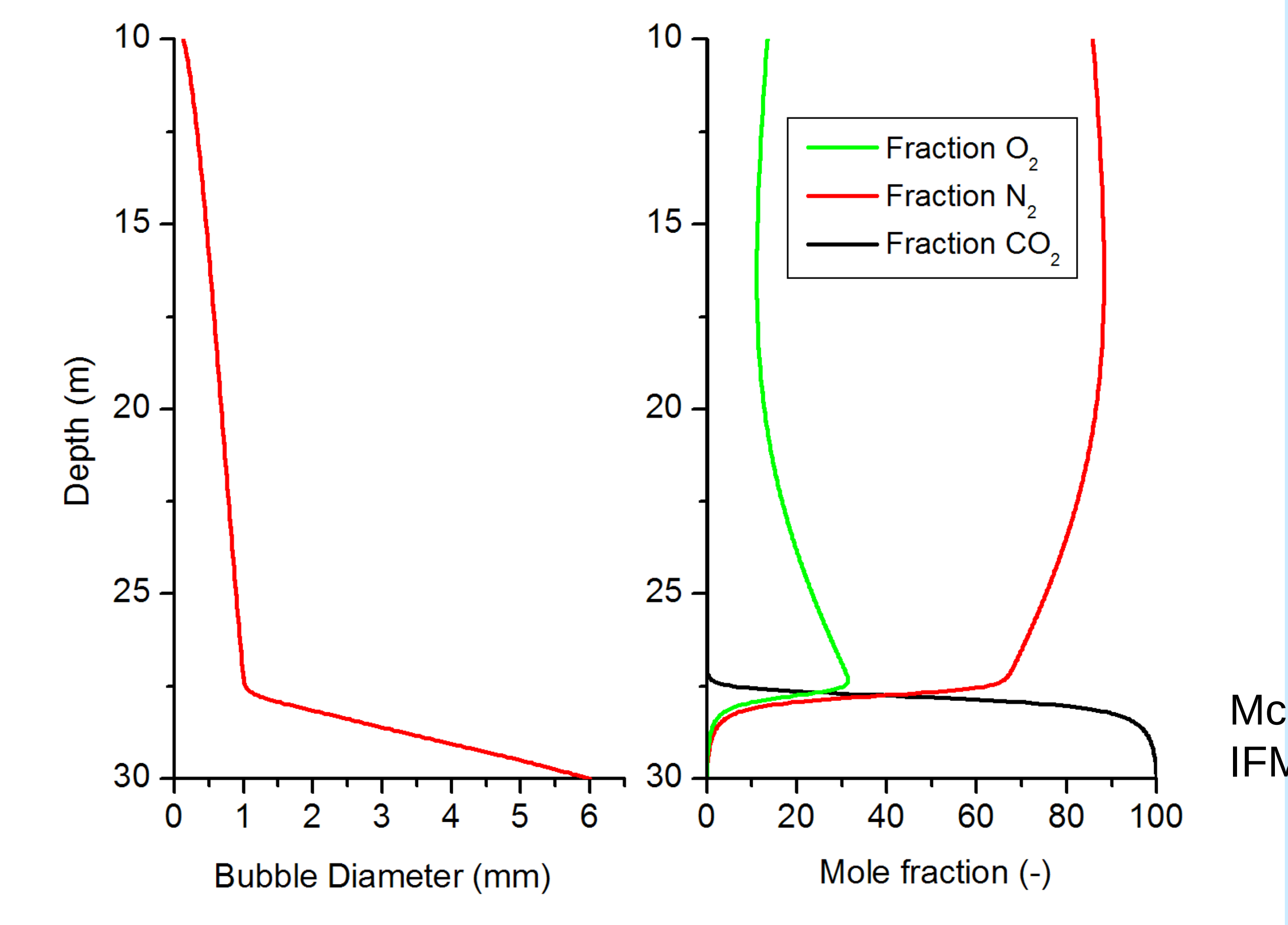
Potential environmental effects of leakage

- Benthic organisms and ecosystems at the storage site may be affected by local acidification of pore fluids and bottom waters through CO_2 leakage and the release of toxic substances dissolved in formation fluids and mobilized from the sedimentary overburden.

- Pelagic ecosystems could be affected by seawater acidification if large scale leakage would occur.

- Atmospheric pCO_2-values might increase under extreme leakage scenarios.

CO_2 bubble plume modeling



McGinnis
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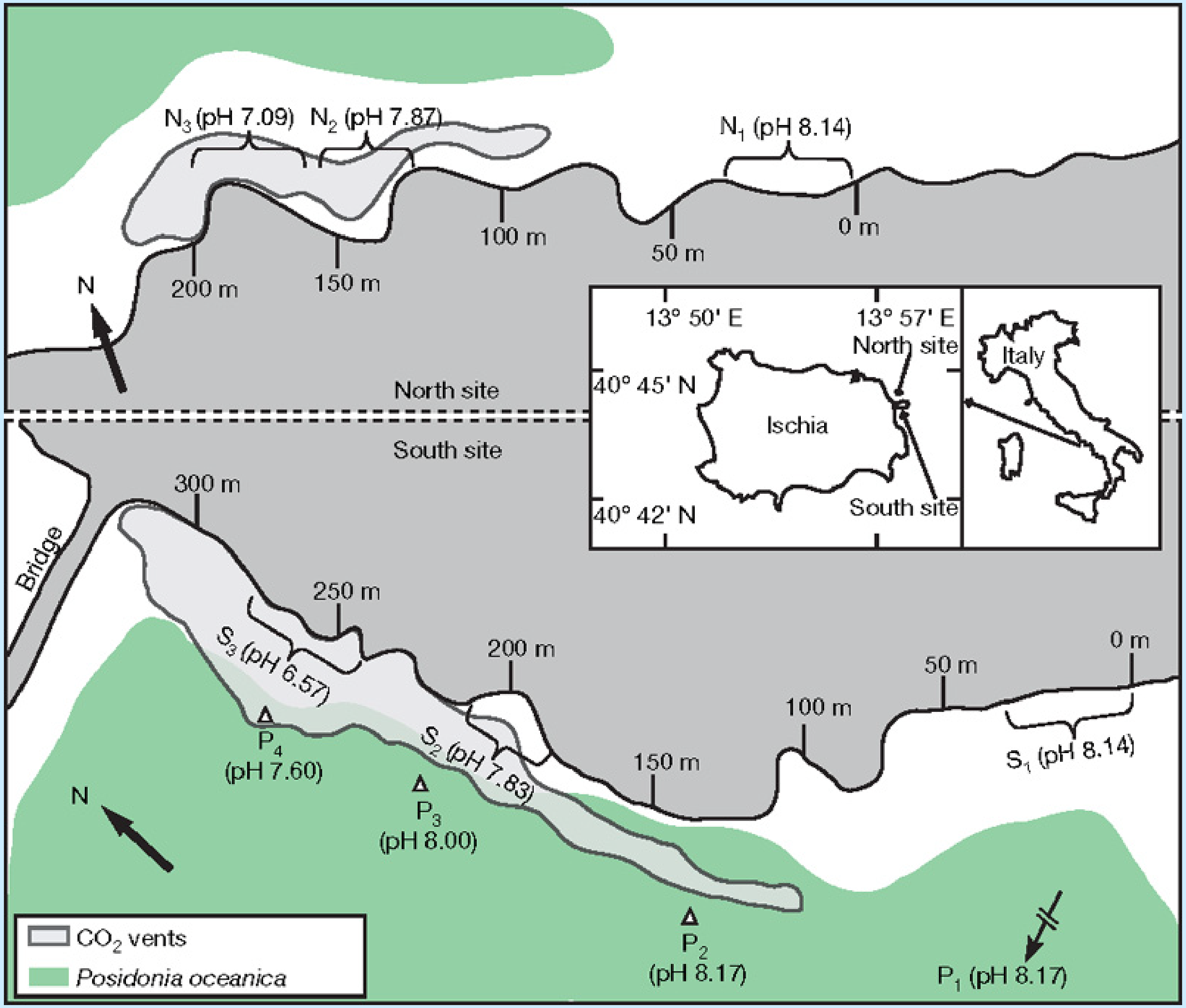
CO_2 bubbles are rapidly dissolved in ambient bottom waters
Atmospheric CO_2 emissions are unlikely to occur

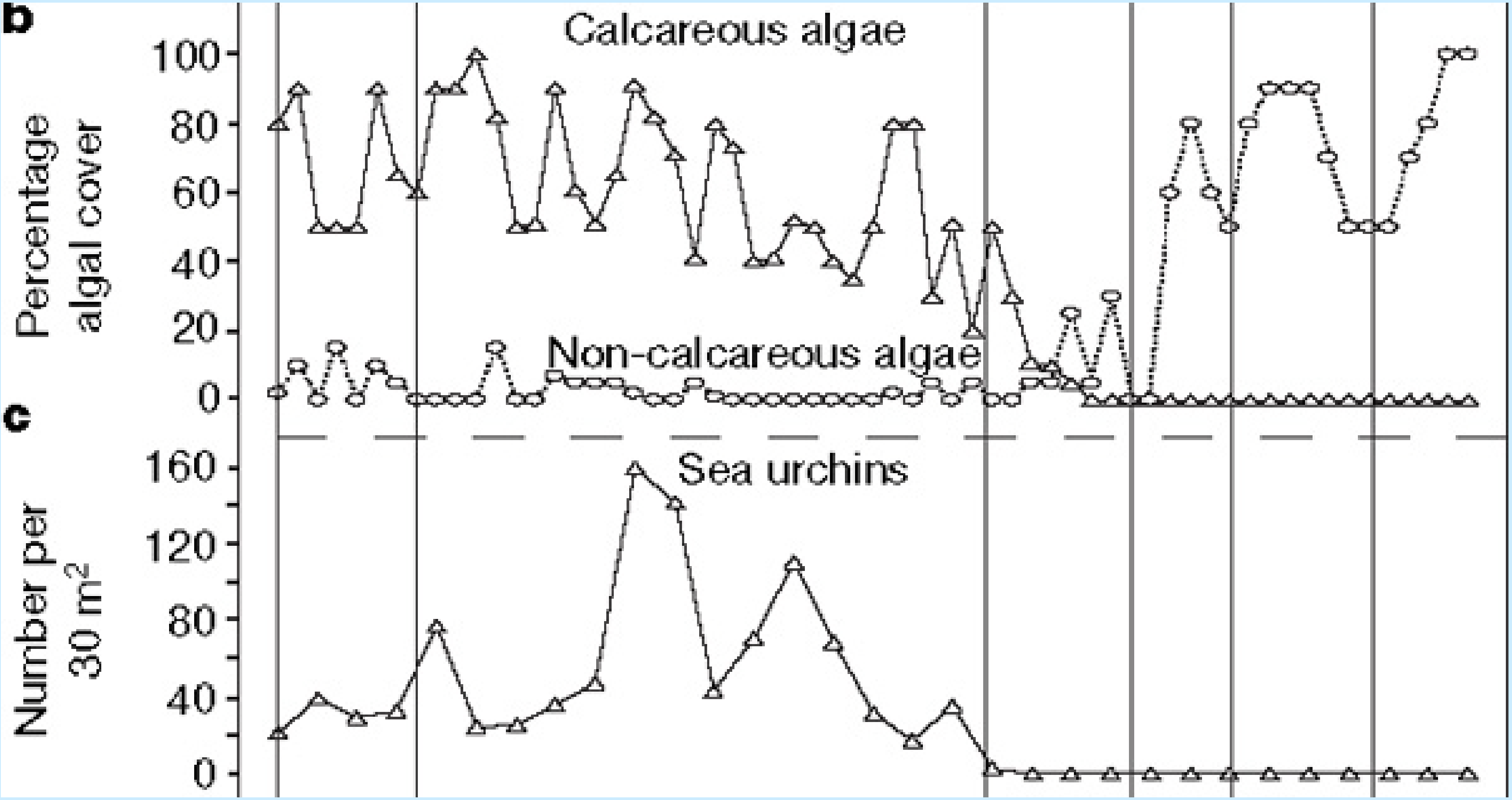
Volcanic CO_2 seeps in the Mediterranean
-Effects on benthic biota-



Source: Hall-Spencer et al. (2008)

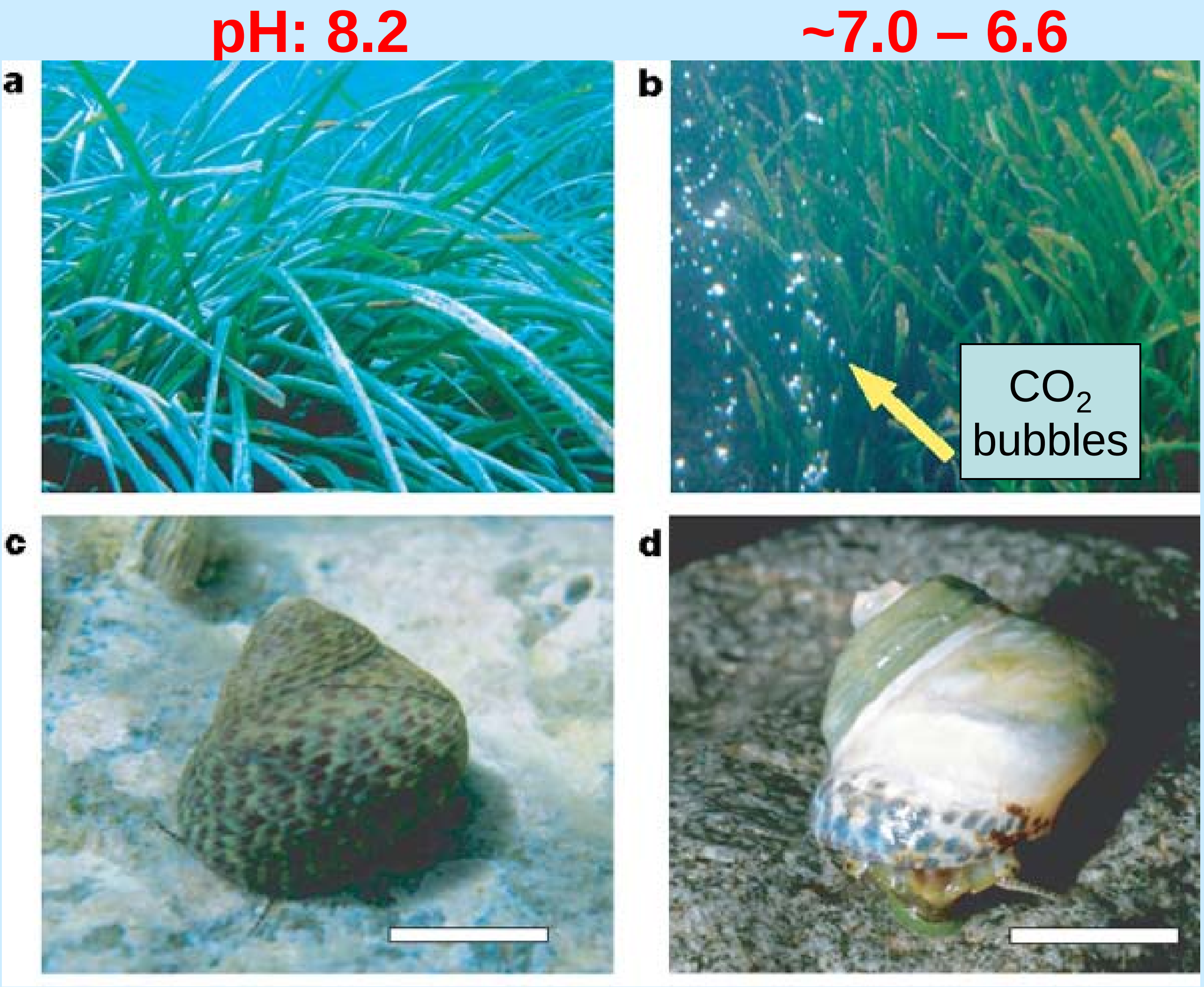
Volcanic CO_2 seeps in the Mediterranean -Effects on benthic biota-

pH: 8.1 7.8 6.6



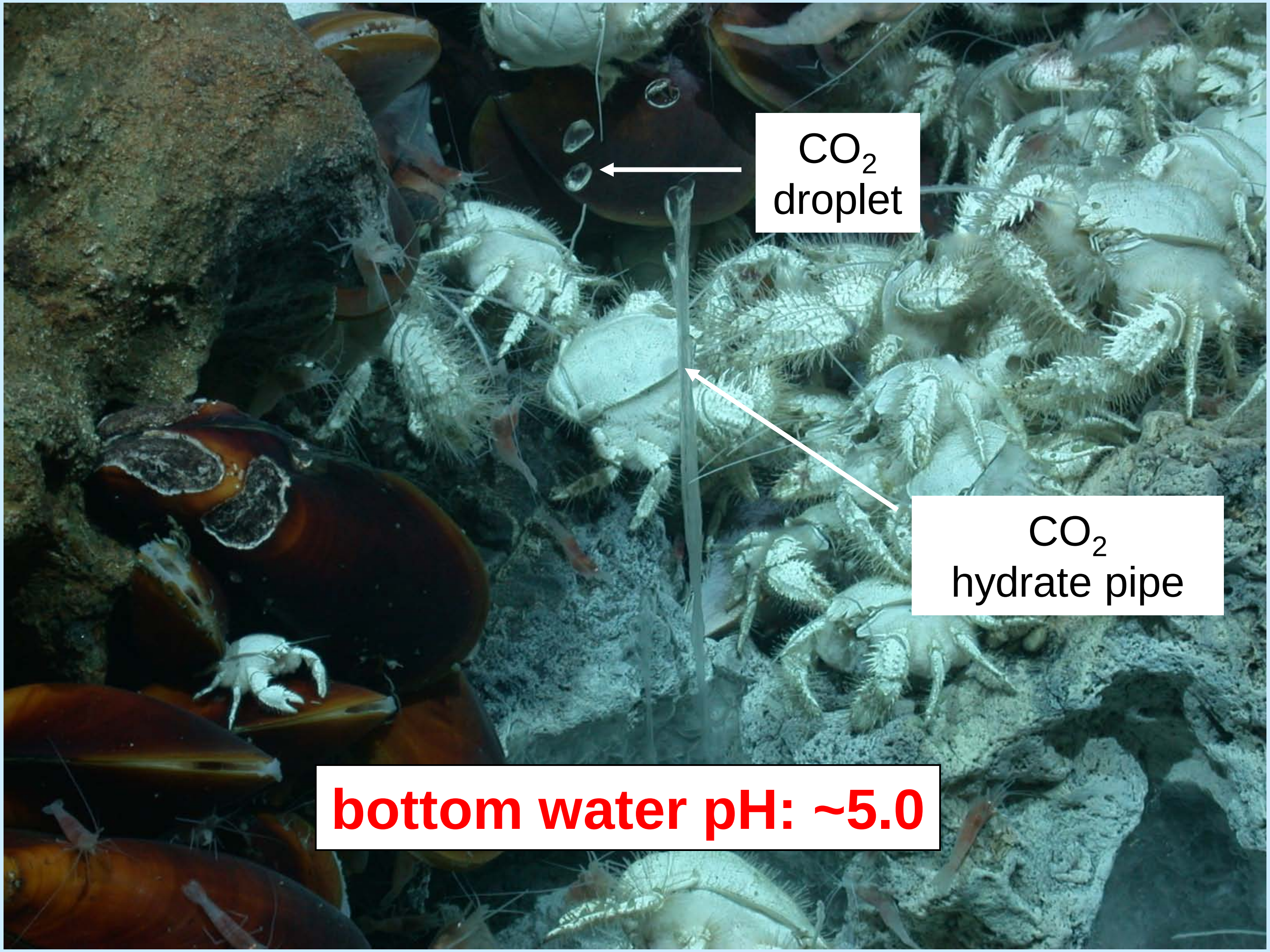
Source: Hall-Spencer et al. (2008)

Volcanic CO_2 seeps in the Mediterranean -Effects on benthic biota-



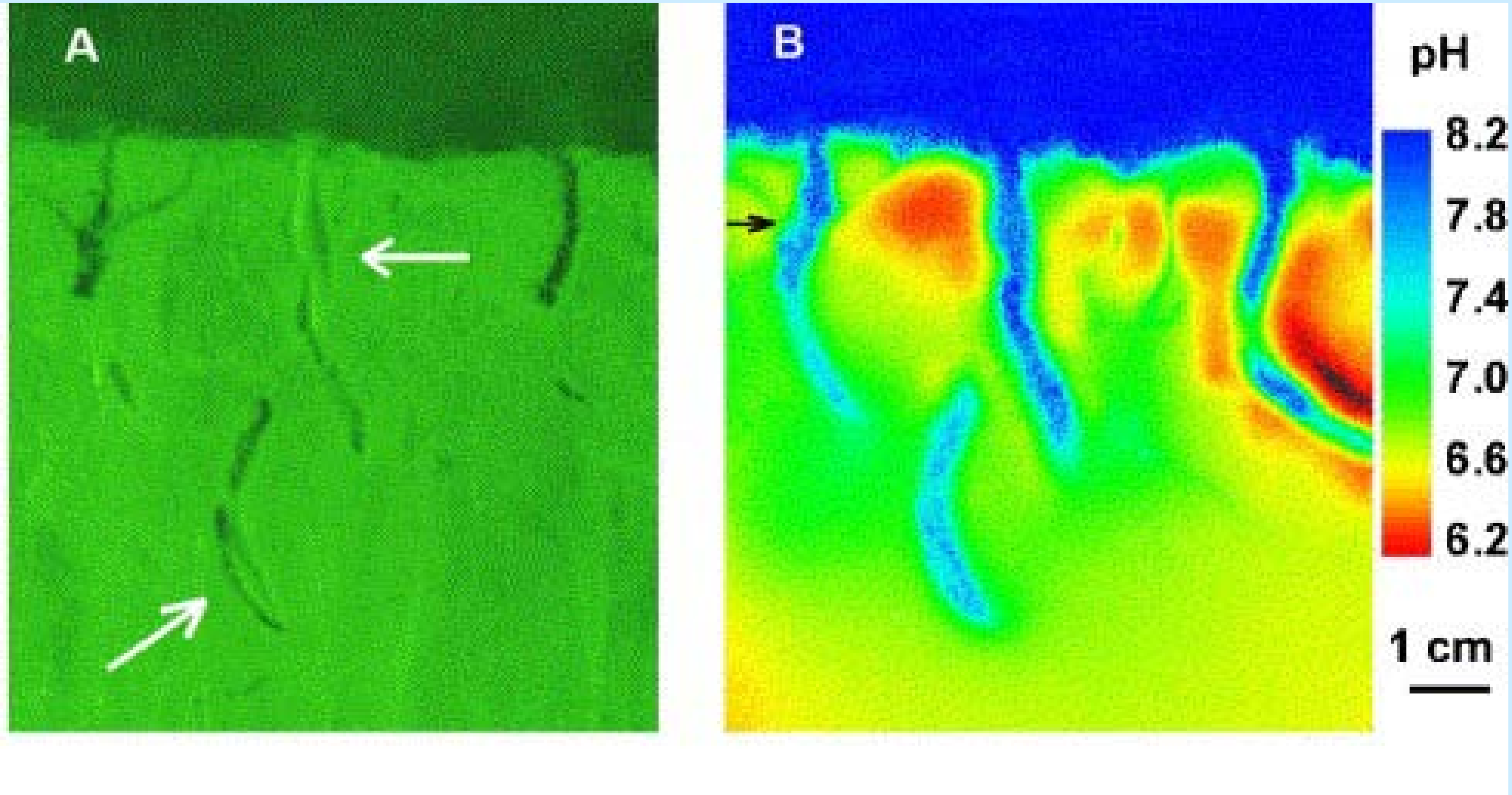
Source: Hall-Spencer et al. (2008)

Seepage of volcanic CO_2 in the Okinawa Trough 2000 m water depth



SO 196, CLATHRATE project, Rehder, Haeckel et al. (unpubl.)

Natural pH variability in shelf surface sediments (no CO_2 seepage)



Source: Zhu et al. (2006)

Research and policy needs (bioscience perspective)

- determine the sensitivity and resilience of benthic organisms towards enhanced CO_2 values in bottom waters and pore waters

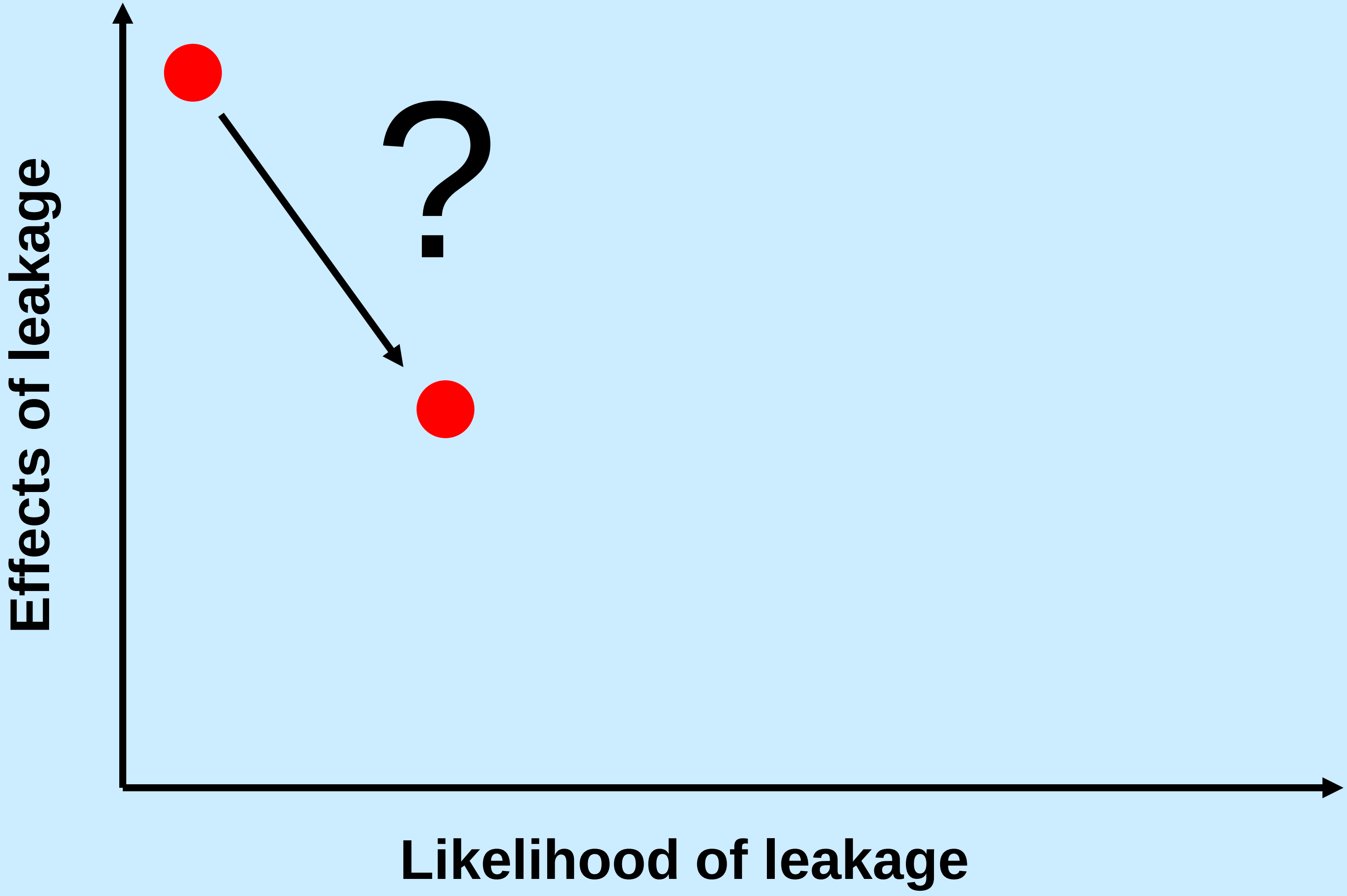
- identify indicator organisms featuring a strong response to elevated CO_2 levels

- characterize and model the effects of CO_2 leakage on benthic and pelagic organisms and ecosystems for different CO_2 emission rates

- identify sensitive areas in the European EEZ that should be excluded from off-shore CO_2 storage activities (potential marine protected areas)

- define a maximum permissible CO_2 leakage rate from an ecosystem perspective

Environmental risk assessment



Conclusions

Given that large-scale storage of CO_2 below the seabed is a corner stone of the European CCS and climate policy, there is an urgent need to:

- **constrain the likelihood of leakage**
- **study the effects of leakage on marine biota and ecosystems**
- **develop a comprehensive monitoring strategy**
- **define the best environmental practices for the operation of storage sites**
- **evaluate the existing legal framework for sub-seabed storage**